ACEEE Int. J. on Signal & Image Processing, Vol. 4, No. 1, Jan 2013

Image De-noising and Enhancement for Salt and Pepper Noise using Genetic Algorithm-Morphological Operations

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***Abstract*— Image Enhancement through De-noising is one of the most important applications of Digital Image Processing and is still a challenging problem. Images are often received in defective conditions due to usage of Poor image sensors, poor data acquisition process and transmission errors etc., which creates problems for the subsequent process to understand such images. The proposed Genetic filter is capable of removing noise while preserving the fine details, as well as structural image content. It can be divided into: (i) de-noising filtering, and (ii) enhancement filtering. Image Denoising and enhancement are essential part of any image processing system, whether the processed information is utilized for visual interpretation or for automatic analysis. The Experimental results performed on a set of standard test images for a wide range of noise corruption levels shows that the proposed filter outperforms standard procedures for salt and pepper removal both visually and in terms of performance measures such as PSNR.Genetic algorithms will definitely helpful in solving various complex image processing tasks in the future.**

***Index Terms*—Genetic Algorithm, Salt and Pepper Noise, Spatial Domain Techniques, Morphological Operations, Structuring Element, PSNR.**

I. Introduction

Image De-noising and Enhancement are the key research fields in Image Processing as they are useful in several applications such as Feature Detection, Medical Image Processing, Remote Sensing, Machine vision etc., which improves the image clarity and visual perception of human beings. They modifies images to improve them (enhancement, restoration), extract information (analysis, recognition), and change their structure. It improves the clarity of the Image for Human Perception. Edge Enhancement, Sharpen (create more contrast between neighboring pixels), Soften (blend the edges of neighboring pixels), Blur removing (blend together pixels of the image), Raising Contrast, Medical Imaging (CT scan and MRI images) are some of the Image Processing functions. Grayscale images are distinct from one-bit black-and-white images, which in the context of computer imaging are images with only the two colors, black, and white (also called *bi-level* or *binary images*). Grayscale images have many shades of gray in between 0 and 255. A 640 x 480 grayscale image requires over 300 KB of storage. Linear and Non Linear Filtering Techniques [1, 5] are used for Image De-noising and Enhancement.Our enhancement operations can be achieved through the process of spatial domain filtering. Spatial Domain filtering simply indicates that the filtering process takes place directly on the Image pixels. Further, morphology encompasses powerful methods which can be precisely treating the Image data mathematically within the framework of set theory.

Digital images are generally affected by different types of noise such as salt and pepper, Impulsive, Gaussian Noise. Salt and Pepper noise may be caused by malfunctioning pixels in camera sensors, faulty memory locations in hardware or transmission in a noisy channel. Spatial Domain transformation functions are generally based on the gray-level distribution in the neighbourhood of each pixel in the given image. In spatial domain methods, the noise is suppressed in the spatial domain itself. Several De-noising algorithms have been proposed by many authors that based on utilizing the information about the neighborhood pixels but they do not give acceptable results. Median filters are the most popular for de-noising in digital images.Applying a set of de-noising and enhancement filters successively on a noisy image may remove noise and preserve image details much more efficiently than a single median filter. When the noise level is high, median filter is not enough for completely removing the noise. So, Nowadays, Researchers and practitioners are increasingly turning towards machine-learning procedures based on Evolutionary Programming such as genetic programming [17] to solve these complex problems.

Morphology [22, 23] is a set theory approach, developed by J.Serra and G. Matheron, process the digital image based on geometrical shape [10, 11] i.e. by applying a structuring element. It has various applications in bio-medical imaging, Geo-science, Remote sensing, Quality control, Document processing and Data analysis. The value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. The extraction and enhancement of shape information from images is one of the important tasks of mathematical morphology [10, 11, 12]. Basic operations of morphology are dilation and erosion. More complicated morphological operators [25] can be designed by means of combining Erosions and Dilations. Dilation adds pixels to the boundaries of objects in an image,

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DOI: 01.IJSIP.4.1.1088

while erosion removes pixels on object boundaries. Depending on the type of the operation, specific characteristics of the objects in the image, like shape, size, neighborhood etc. can be taken into an account. Some expert knowledge is necessary to properly select the structuring element (SE) and the morphological operators to solve a certain problem [6].

The paper is organized as follows. Section 1 discusses about some basic concepts related to Image De-noising and Enhancement. Section 2 discusses about several spatial Domain Image denoising and Enhancement methods for various applications. In Section 3, we proposed a method for removing salt and pepper noise using Genetic Algorithm and morphological operations. We performed experiments on several images in Section 4.Finaly section 5 concludes the work.

II. Literature Survey: A Review

In this section, a handful of recent research works available in the literature for reducing noise and enhancing the images are briefly reviewed. Traditional Median Filter [1] is effective in reducing the salt and pepper noise as well as preserving boarder. But it works well for low noise levels (Up to 50%). H. Hwang proposed Adaptive Median Filter [2], which also works well for low noise levels. As noise level increases the Image will become blurred. K. S. Srinivasan proposed a Decision based noise reduction method [3] which works well for medium range of noise levels. A Method with hybrid Image Enhancement Technique for Noisy Dim Images Using Curvelet and Morphology have established by Muthu Selvi, Roselin and Kavitha [4]. This paper gives the new method for enhance the noisy dim image and improve the quality of the image. Morphological operations *opening by reconstruction* and *closing by reconstruction* are applied to the Image and then the gamma function is applied for the purpose of illumination Correction. Morphological reconstruction filter *closing by reconstruction* has been found to produce better result compared to *opening by reconstruction*. Jimenez Sanchez *et al*. [6] proposed a method to detect the image background and to enhance the contrast in grey level images with poor lighting, in which an approximation to the background using blocks analysis is computed. This was subsequently extended using mathematical morphology operators. However, a difficulty was detected when the morphological dilation and erosion were employed. Therefore, a new method to detect the image background was proposed, which is based on the use of morphological connected transformations. These morphological contrast enhancement transformations are based on Weber's law. But they can only be used satisfactorily in images with poor lighting. Rafael Verdú Monedero *et al* [7] proposed a spatially variant erosions/ dilations and openings/closings approach. Structuring elements (SE) can locally adapt their shape and orientation across the direction of the structures in the image. The process of extracting shape and orientation of the SE at each pixel from the image is under study. This method is useful in the enhancement of anisotropic features such as coherent, flow-like structures. A general method based on fuzzy implication and inclusion grade operators have been discussed by Yee Yee Htun *et al* [8].The fuzzy morphological operations have extended the ordinary morphological operations by using fuzzy sets, where the union operation and the intersection operation of the fuzzy sets have been replaced by a maximum operation, and a minimum operation respectively. In this work, fuzzy set theory, fuzzy Mathematical Morphology based on fuzzy logic and fuzzy set theory, fuzzy Mathematical operations and their properties have been studied. The applications of fuzziness in Mathematical morphology in practical work such as image processing and illustration problems have been discussed. Fuzzy Filtering [9] also useful in Image Enhancement in which spatial data is transformed to Fuzzy Data and Fuzzy operations were carried out on this data and Finally converting the modified Fuzzy Data to Spatial Data. Morphological operations [24] are useful in smoothing the Images. But they also remove thin features from the images along with noise. Morphological Image Cleaning algorithm which is explained in [11] preserves thin features while removing noise. This algorithm is best useful for Scanner noise, still video images noise etc.

R.Chan et al proposed a filter [13], where the noisy pixel detection is carried out by using an adaptive median filter that is able to remove high salt and pepper noise .In this work the performance of this powerful filter is analyzed with various standard images. The proposed filter consists of two important phases: 1) The noise candidates are first identified by a detector based on Adaptive Median Filter and then 2) These noise candidates are selectively restored using an objective function with a data-fidelity term and an edge-preserving regularization term. Moreover, application of median filter to an image requires some caution because it tends to remove image details while removing noise. However, the performance of median filtering is unsatisfactory when the noise percentage is quite high and suppressing signal-dependent noise. Jin Hyuk Hong, Sung Bae Cho and Ung Keun Cho proposed a method that uses Genetic Algorithm (GA) [14] that remove different levels of impulse noise from an image [15].They have extended this method to performs local and global image enhancement [16]. In this work, GA selects the best combinations among them according to a fitness value assigned to each combination based on a fitness function, and applies operators such as crossover and mutation [14] on the selected combinations to create the next generation. This process is repeated, enabling GA to find the optimal filters. In the work in [15] and [16], GA parameters, which affect the quality of the solutions produced, are kept fixed. If these parameters are not assigned with suitable values, GA may take a long time to converge to the optimal solution or it may converge to a sub optimal solution. However, choosing the best parameter values is difficult because the parameter values are problem dependent.

Nikolova [18] proposed a variational method for image details preserving that is based on a data-fidelity and for edge preserving in salt and pepper de-noising. The NLM

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DOI: 01.IJSIP.4.1.1088

filter, which is introduced by Buades in 2005 [19] relies on the weighted average of all pixel intensities where the family of weights depends on the similarity between the pixels and the neighborhood of the pixel being processed. The proposed method outperforms the Standard Median Filter and Adaptive Median Filter.

III. Proposed System

A. Salt and Pepper Noise Reduction Using GA

Genetic algorithms are based on natural selection of fit-test individuals as optimization problem solver. Optimization is performed through natural exchange of genetic parameters between parent genes. Offsprings are formed from parent genes. Fitness of offsprings is evaluated. The fittest individuals are allowed to breed only. In this work, genes are replaced by strings of bits and natural selection replaced by fitness function. Reproduction from Matting of parents is represented by cross-over and mutation operations. The crossover operator takes two parent bit strings, splits them at a random place and swaps the sub-strings so formed. A probability of crossover determines whether a crossover should be performed. The mutation operator inverts a bit in the bit string depending on the probability of mutation. The new strings formed are evaluated and the iteration continues until a maximum number of new generations has been reached or until a user defined termination criterion has been met. Figure 1 shows the sequence of steps in our proposed genetic algorithm. There are some control parameters that have to be specified initially such as population size, the crossover and mutation probabilities, the maximum number of generations and the termination criterion. Crossover operates by selecting a random bit in the genetic string of the parents (crossover point) and concatenating the initial segment of one parent string with the final segment of the second parent string to create a new child string. A second child is simultaneously generated using the remaining segments of the two parents .Mutation inverts one or more genetic elements which are produced by crossover during reproduction.

Proposed GA process (Figure 1) consists of five steps:

1. Start with a randomly generated genes of N chromosomes, where N is the size of genes bit strings, l – length of chromosome x.
2. Calculate the fitness value of function φ(x) of each chromosome x in the population.
3. Repeat until Termination Criteria :
3.1. Select a pair of chromosomes from parent bit streams using value of fitness function.
3.2. Perform Crossover and Mutation.
4. Replace current generation with newly created one.
5. Go to step 2.

B. Morphological Operaton

After Boarder preserving De-noising the Image morphological imopen function is performed on the Image with a 3×3 disk structuring element (SE). Morphological operations produce smooth Image than original as shown in the results. They can process according to the shape of SE. Dilation and Erosion are the two basic Morphological Operators. Erosion shrinks the boundaries so that holes in the region become larger where as Dilation enlarges the boundaries so that holes in the region become smaller. Erosion and Dilation are often used in combination to implement image enhancement operations known as "Opening" and "Closing"," Opening" is performed through combination of erosion and dilation i.e erosion followed by dilation, which is less destructive than Erosion alone. "," Closing" is performed through combination of dilation and erosion i.e dilation followed by erosion.

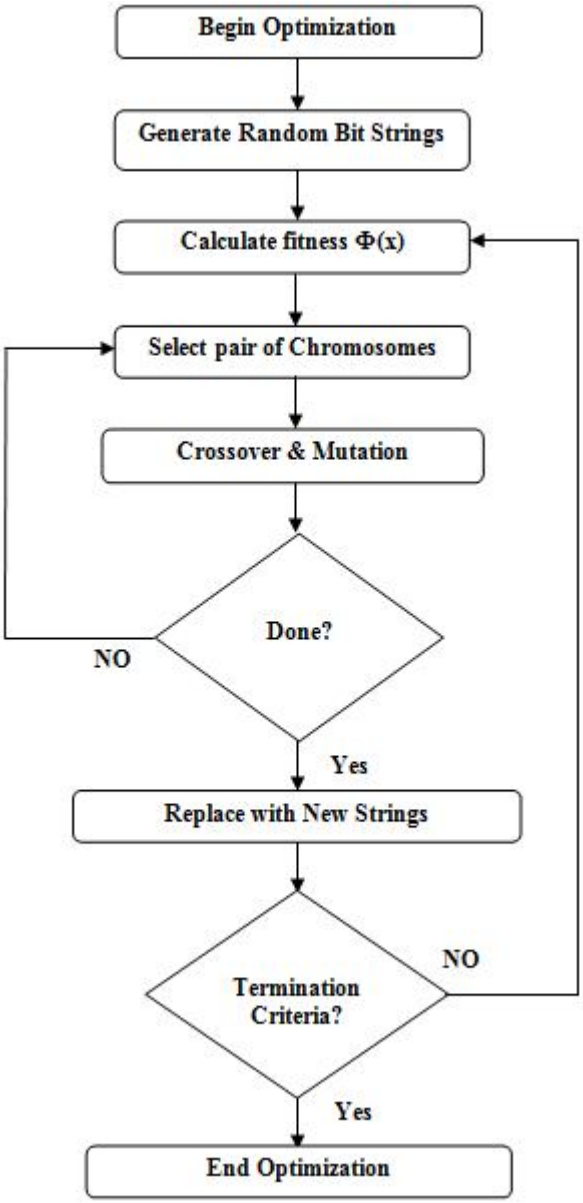

Fig1.Genetic Algorithm Process

IV. Results and Discussion

A. Results

The proposed image De-noising and Enhancement using Genetic Filter and morphological operations was implemented

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DOI: 01.IJSIP.4.1.1088

in the working platform of MATLAB (version 7.10) and obtained the results which are shown in Fig 2 and Fig 3. The enhancing process of the proposed system was evaluated with different standard images like Lena, Baboon, cameraman, House etc. Using these Images this work was tested by color and grayscale Images by applying the Genetic Algorithm and morphological operation "imopen".

TABLE I. COMPARISON OF PSNR VALUES OF LENA IMAGE AT NOISE DENSITIES 20%, 50% AND 80%

Noise Level	PSNR in dB		
	Proposed Method	Our Previous Work [20]	Previous Work [21]
80%	24.89	24.44	----
50%	32.17	31.06	27.29
20%	35.39	35.23	31.51

Fig 2: Results of proposed Method for Lena Images (a) Original Lena Image (b) Lena Image Corrupted with 10%,30%, and 60% Salt and Pepper Noise (c) Noise Reduced by Proposed Filter

A fitness function is computed to find whether the generated chromosomes are fit to survive or not, can be given as

$$f_i(j) = (1/n) \sum_{0}^{n-1} D_{ijk} \quad (1)$$

Fig 3: Results of proposed Method for Gray Scale Barbara Images (a) Barbara Image (b) Corrupted with 70% and 80% Salt and Pepper Noise (c) Noise Reduced by Proposed Filter

where, $fi\,(j)$ is the fitness of the the j^{th} chromosome generated for the i^{th} window and D is the norm distance determined between the *wi* and the window indexed by the k^{th} gene of the l^{th} chromosome.

The peak signal-to-noise ratio (PSNR) is expressed as equation 2

$$PSNR = 10\log_{10} 255^2/MSE \quad (2)$$

PSNR Values of Lena image at different noise densities are compared with different enhancement techniques, provided in the Table I.

B. Discussion

Proposed Algorithm to de-noise and enhance the Images using GA Filter and Morphological operations does not require complicated calculation to enhance image contrast value. It performs well up to 80% of salt and pepper noise. If the noise level is equal or above 90% then this algorithm produces the blurred Images.

V. CONCLUSION

In this Paper, a hybrid image de-noising and enhancement technique that combines Genetic Filter and morphological operation is implemented. Initially, the Original Image is filtered using Genetic Filter and then enhanced using Morphological Operation. The implemented Algorithm present the best performance both visually and quantitatively based on the measures such as mean square Error (MSE), Peak Signal to noise ratio (PSNR). This paper considers the morphological open function with3 X 3 square structural elements for smoothening. Experiments were carried out on number of Images, with the different noise levels i.e very low noise level to very high noise levels. The result was robust and achieved a very good enhancement Level which proves the effectiveness of the Proposed Work.

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DOI: 01.IJSIP.4.1.1088

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DOI: 01.IJSIP.4.1.1088